

The Vibration test and Improvement of the TPS Prototype Girder

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Abstract

A prototype of magnet girder system for the Taiwan Photon Source (TPS) project has been fabricated and installed. The prototype girder was assembled with one dipole and 6 quadrupole magnets to simulate the operation situation. The total weight of this system is about 10 tons. The goal of this study is to realize the vibration properties of the prototype girder system under different conditions such as improved mechanisms installed/uninstalled and cooling water system on/off. Modal testing was performed to obtain natural frequencies and natural modes of the girder system. According to the results of these tests, some mechanisms such as spring system and wedge locking system have been applied to increase the stiffness between the girder and the pedestals or decrease the vibration amplification factor. After they were installed, the first natural frequency of the magnet girder system could be raised to higher than 29.5Hz. In this paper, the results of vibration properties measurement and the improved mechanisms design is presented.

Introduction

A precise 6-axis prototype girder system was designed and it has been fabricated and installed at NSRRC [1]. Each girder was supported with 6 cam movers on 3 pedestals to be adjusted by 6 motors. Girder 2 (G2) which is in the middle of the prototype girder system was assembled with one TLS backup dipole and 6 TLS backup quadrupole magnets for testing and was called G2 testing system shown as in the fig. 1.

As the power spectrum density (PSD) decreases with increasing frequency from the PSD measurement at NSRRC site [2], higher resonant frequency of the girder is demanded to reduce the vibration of magnets. Besides, according to the general agreement of the mini workshop held in NSRRC in August, 2005, our desired natural frequencies of the girder-magnet assembly were suggested to be higher than 30Hz. However, the preliminary test before shows that the first natural frequency of the girder without the mounting dipole magnet is lower than 30Hz [1]. The total weight of the G2 mounted with one dipole and 6 quadrupole magnets is roughly 10 tons, however, its natural frequencies is not mentioned in [1]. Therefore, vibration properties of the G2 testing system should be further investigated and improved mechanisms should be designed to make natural frequencies of the girder higher. In this study, the design consideration of the improved mechanisms would be presented and the vibration properties of G2 testing system equipped with different improved mechanisms were obtained. Furthermore, a preliminary test of the cooling water induced vibration has also been performed.

Mode Frequency and Mode Shapes Before/After Installing the Wedge Locking System



Fig. 1:Prototype girder with magnets



Fig. 9: Wedge locking system

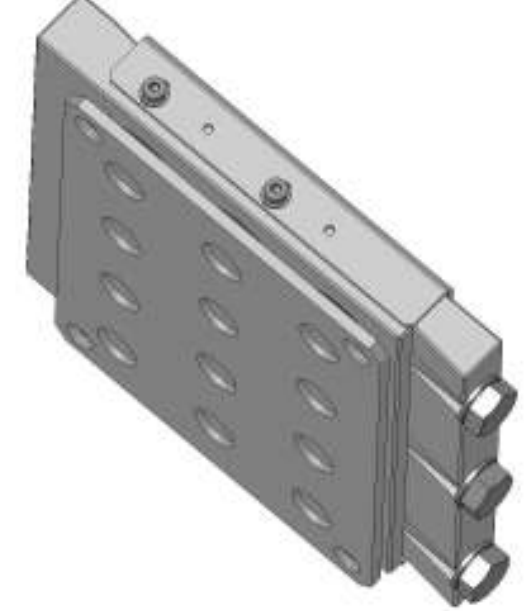


Fig.10: A wedge module

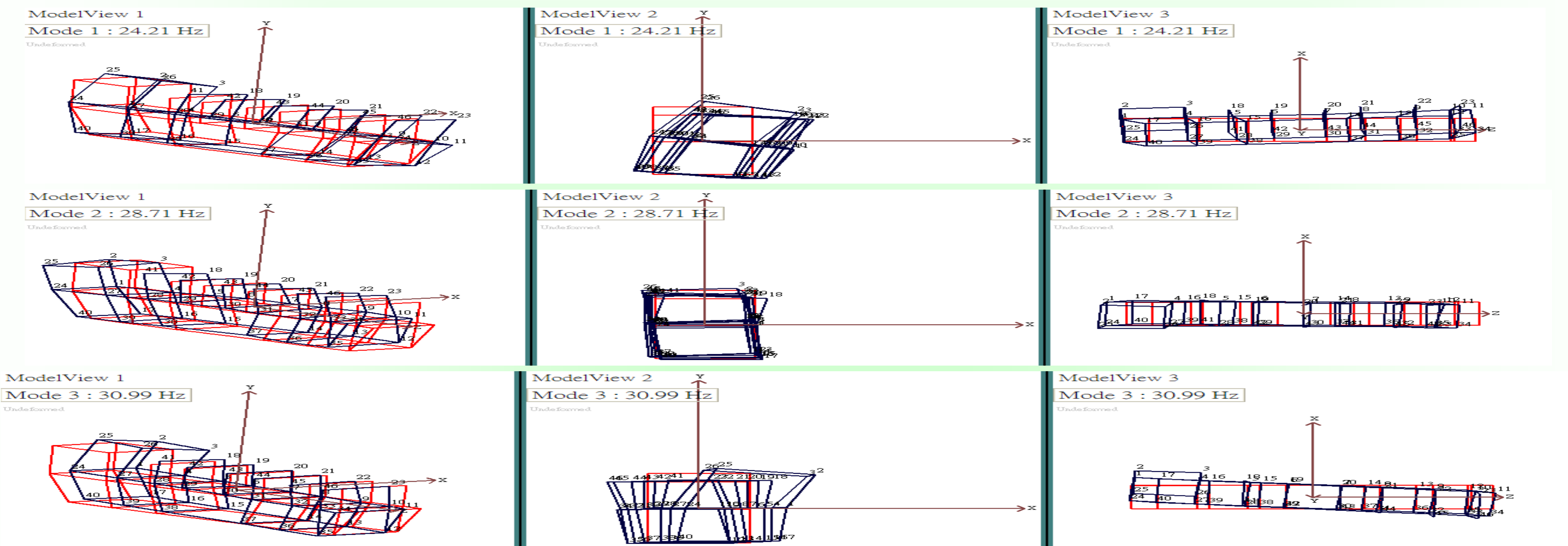


Fig. 3~5: Mode shapes before installing the wedge system

Table 1: Model testing results of G2 before improvement

Mode	Frequency (Hz)	Mode shapes
1	24.21	G2_rolling&yawing
2	28.71	G2_Z-translation
3	30.99	G2_yawing

Table 2: Model testing results of G2 after improvement

Mode	Frequency (Hz)	Mode shapes
1	29.65	G2_rolling
2	35.31	G2_yawing
3	39.35	G2_Z-translation

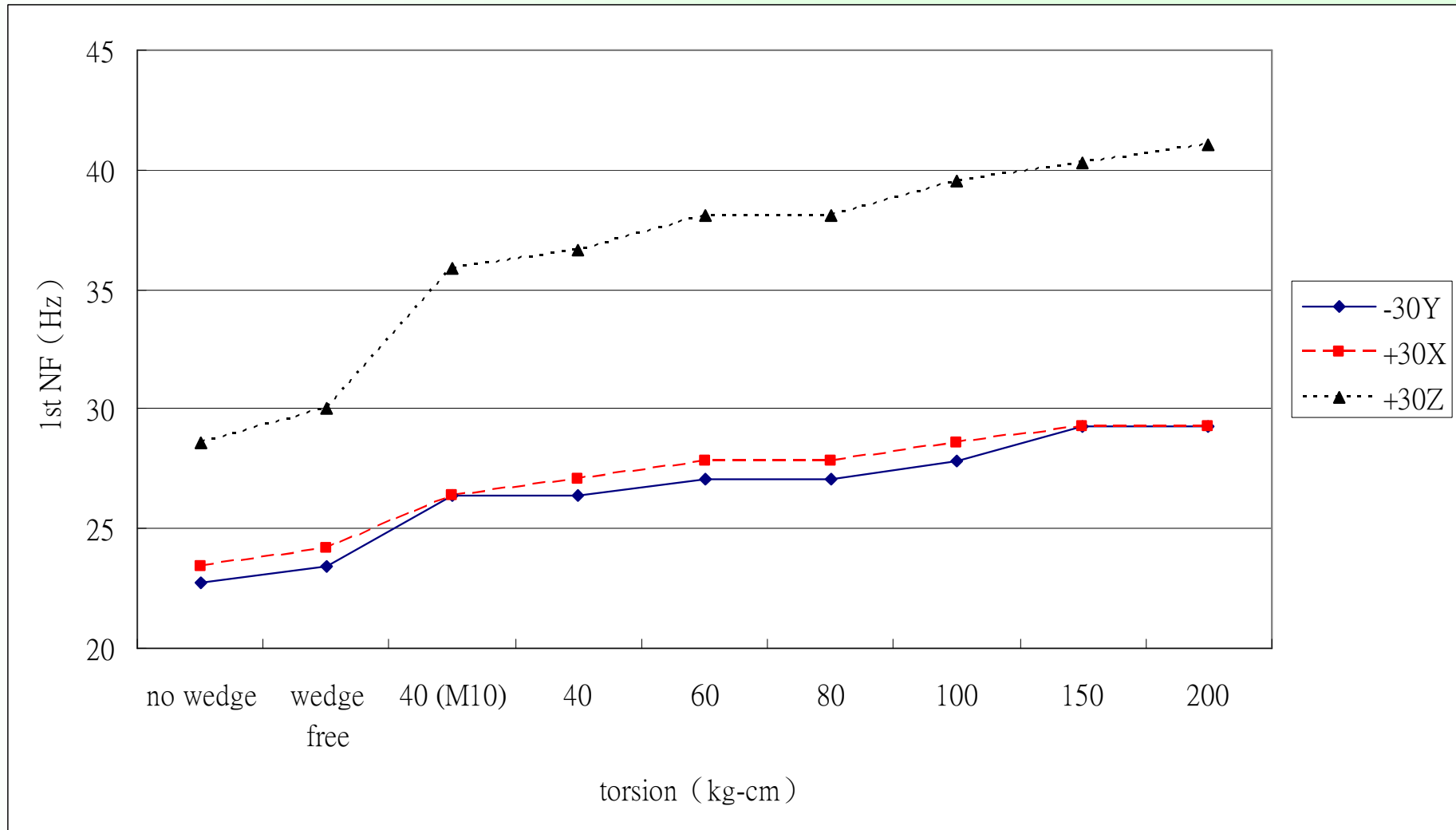


Fig. 11: The 1st NF of G2 under different torsion of the wedge system

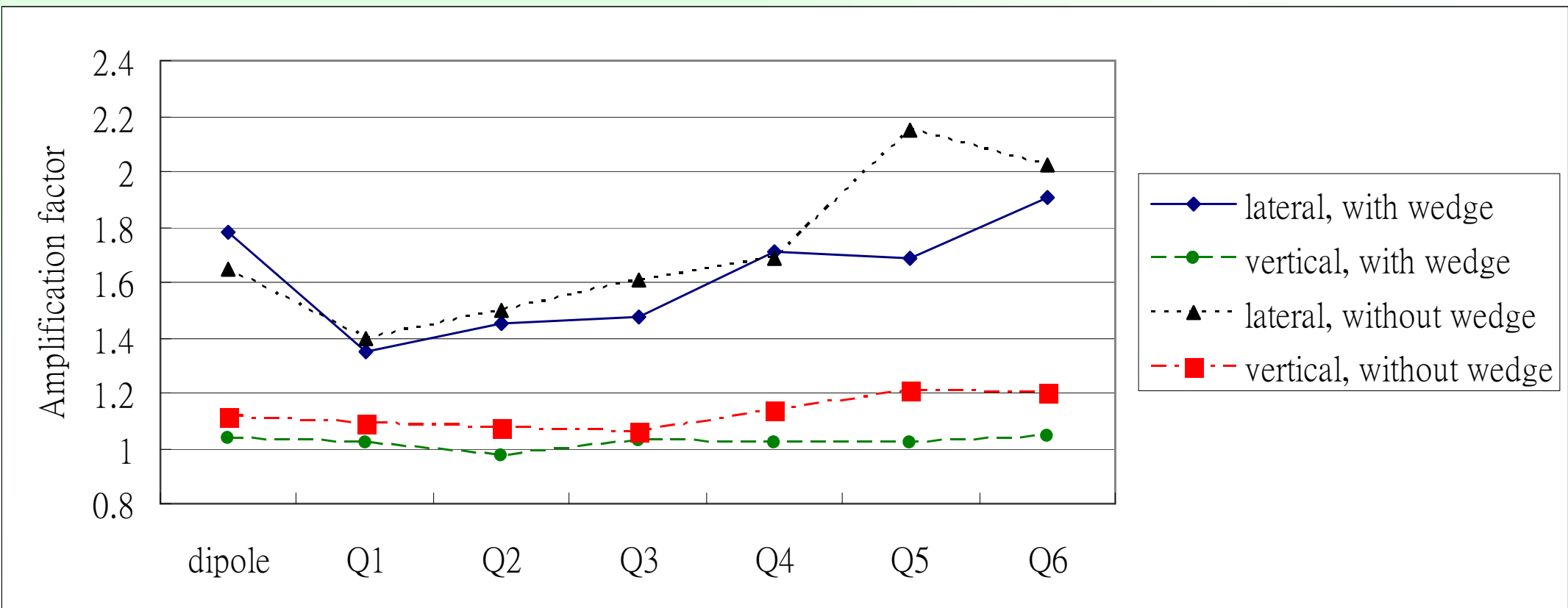


Fig. 15: Amplification factor of magnets with/without wedge system

Design and test results of spring system



Fig.6: Tensional spring systems connected girder to pedestals

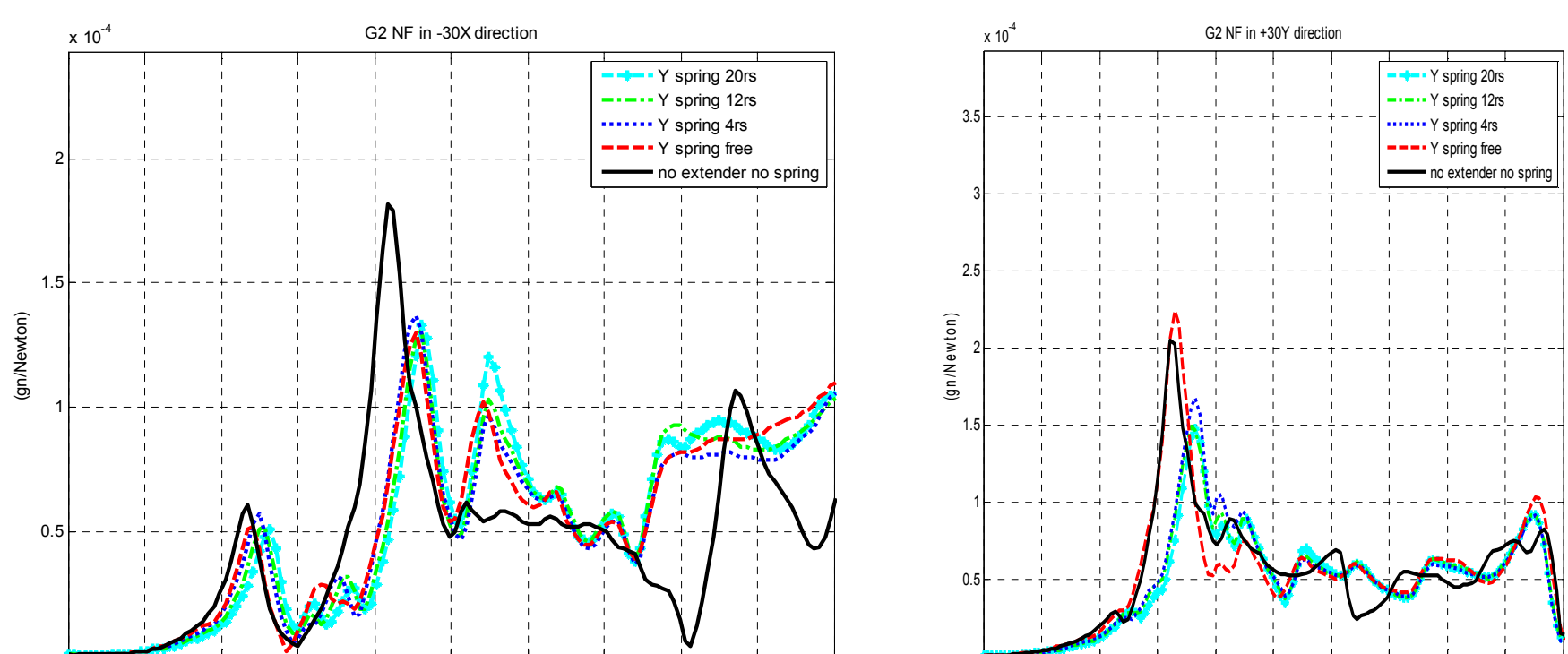


Fig. 13: The lateral (L) and vertical (R) frequency response of G2 under different spring force

Vibration Test of Cooling Water System

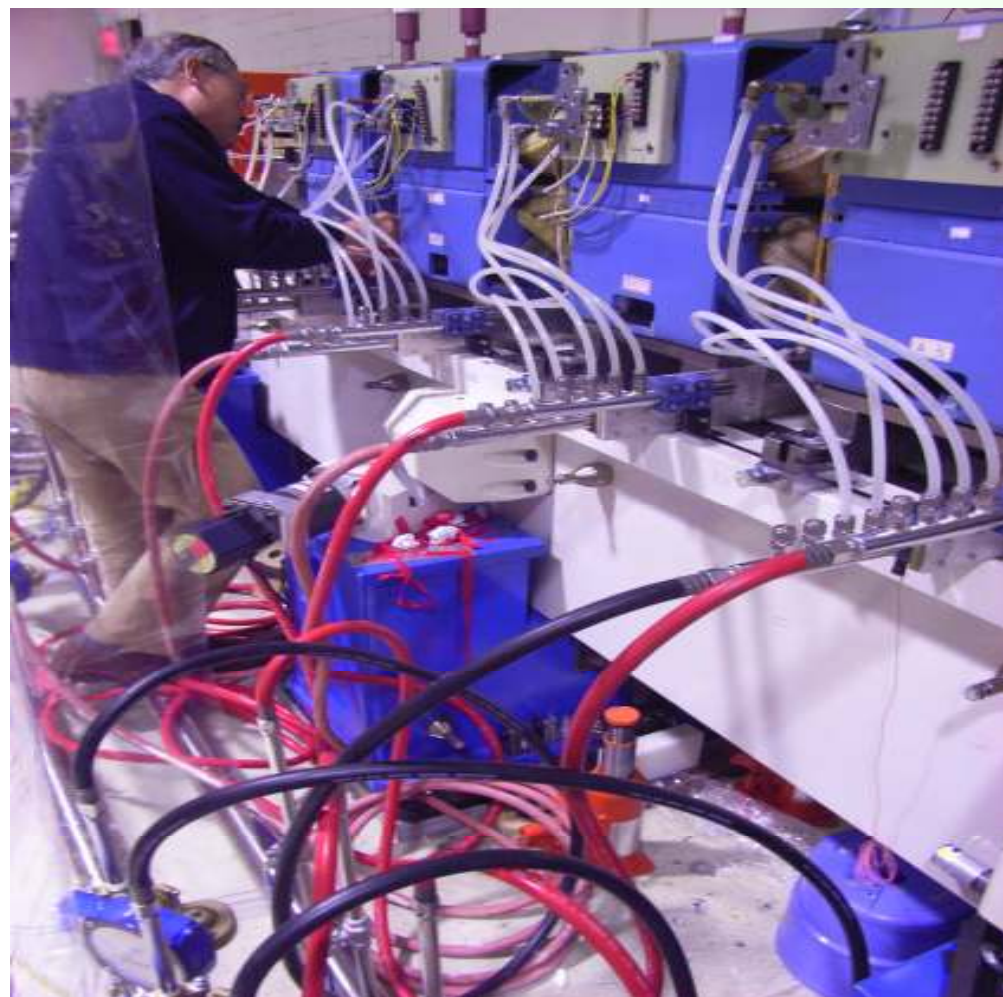


Fig. 16: Cooling water vibration test

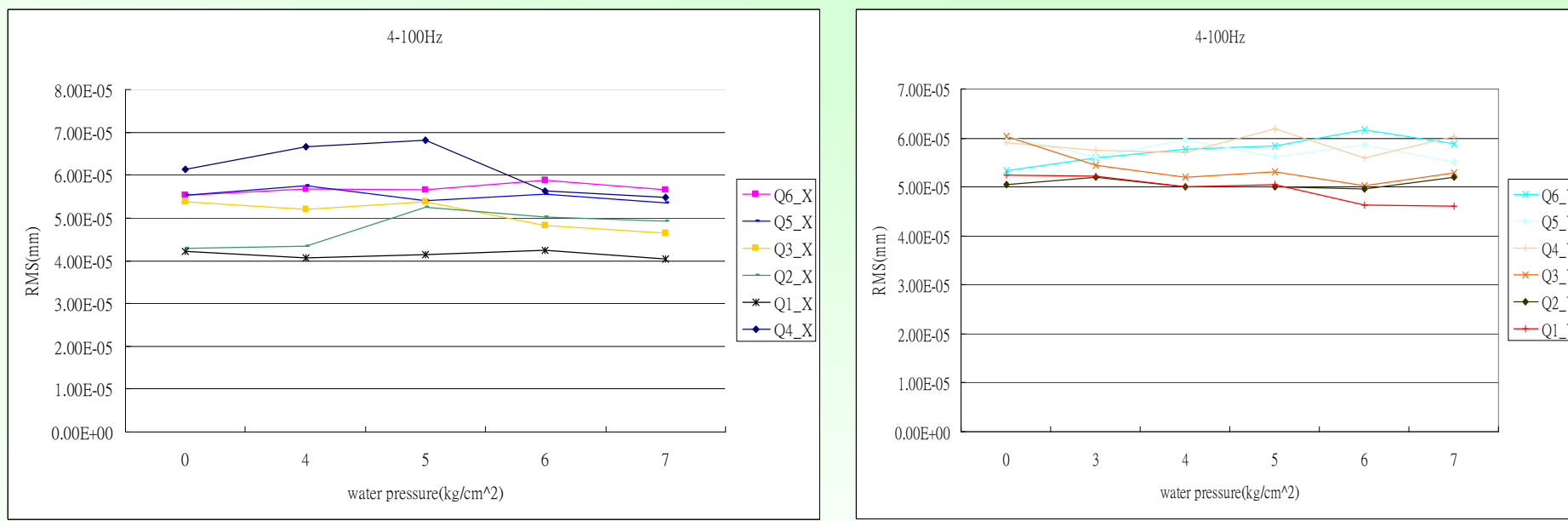


Fig. 17、18: RMS displacement of cooling water vibration test in the horizontal and vertical direction respectively.

Discussion

The model testing of G2 before improvement showed that the 1st natural frequency of G2 was 24.2Hz and its natural mode was a combination of rolling and yawing. After applying the improved mechanism such as the spring system or the locking wedge system, the first few natural frequencies of G2 were higher due to increasing the stiffness between the girder and pedestals. After installing the wedge system, the 1st natural frequency of G2 was raised to 29.65Hz and its natural mode became purer rolling, though the magnet bases were installed on G2. In addition, the amplification factor of G2 with the wedge system was almost less than that without the wedge system. The preliminary water induced vibration testing of prototype girder showed that the water induced vibration was not significant. Nevertheless, the pumping system, the sub-pipes, the magnet coils and the magnets would not be the same with the future design. So the study of water induced vibration should be researched in depth.

This study showed that the wedge locking system were much more effective to increasing the first natural frequency of the prototype girder designed by NSRRC. On the contrary, the wedge system might affect the adjustment and alignment of the girder system due to the unbalanced forces from different wedge modules. So in the future, further research should be emphasized on the feedback control mechanism of the wedge system to make the precise position of the girder.